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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

PUBLISHED BY
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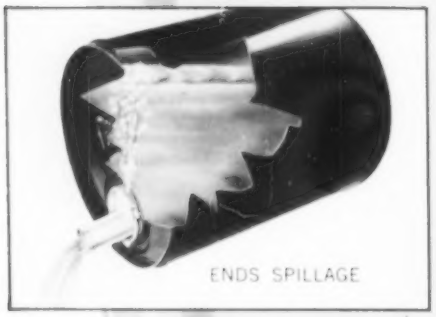
TEXACO PETROLEUM PRODUCTS



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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

Published by

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PACKAGING PETROLEUM PRODUCTS

THE process of converting a sheet of bare metal into brightly lithographed multi-colored cans of many sizes and shapes, filling them with an exact volume of oil and closing them for shipment at a rate of 600 cans per minute—10 cans per second—may seem fantastic, but is real. One must look twice to believe it. This remarkable achievement has been accomplished by the industry's development of rapidly-operating precision machines to accomplish each of the many steps in this conversion process. The trouble-free operation of each of these units depends upon a well organized lubrication program which insures the application of the right amount of the right lubricant at the right place and right time.

The petroleum industry is one of the major consumers of tin cans but it cannot claim credit for the rapid strides made in can making and filling equipment. This belongs to the food and beverage industries, which use approximately eighty per cent of all cans manufactured. Oldsters recalling the turn of the century can reminisce on the passing of the bulk handling of many common items. It is with some regrets that pickle and cracker barrels, wooden candy pails and coffee and sugar bins have disappeared from the village store but the wooden "stove oil" barrels to which frequent pilgrimages were made to fill gallon cans for replenishing lamp and stove reservoirs will not be missed. These are only a few of many similar sights that have disappeared with the passing of a period which has been marked by great progress in the packaging of commodities in sealed containers made from glass, aluminum, plastic or steel. This evolution is not surprising since it had as its specific targets the elimination of leakage and spoilage, while promoting the availability of otherwise perishable products, easy handling and convenience of use. The single factor contributing most to the miraculous growth of the can industry is the ability of these containers to preserve food products for long periods of time. This not only insures a steady food supply for a rapidly increasing population in the urban areas, but permits farmers to raise much larger crops for much wider distribution to more markets. Cans also enhance the enjoyment of eating by making seasonal and foreign delicacies widely available throughout the year. They also make food available to arid and frigid areas which are not self sufficient in this respect.

While the can and food industries are mutually inter-dependent, the convenience and economy of can packaging for other products has given considerable impetus to the can industry. The marketing of petroleum products is one of the more important of these.

In spite of the present importance of the can in

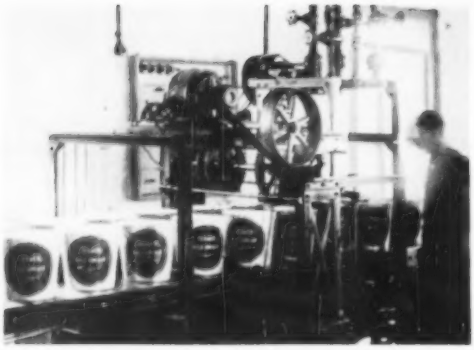


Figure 1 — Packaging wagon axle grease in reusable pails about fifty years ago.

this "tin can" civilization, these containers do not enjoy an unusually long history. They are a very good confirmation of the adage, "Necessity is the mother of invention." Late in the eighteenth century the French Government recognized the importance of preserving food to sustain its armies fighting in foreign lands. A sizable reward was offered to the first one accomplishing this objective. It seems only logical that the winner was an experienced brewer, pickle maker and vintner, one Monsieur Nicholas Appert. His solution, equally logical, was to preserve food in glass bottles, the same as wines. Appert conducted many experiments in which partly cooked foods were placed in bottles which were then sealed with corks and immersed in boiling water to complete the cooking and sterilization process. More than fifty foods preserved in this manner retained their flavor and wholesomeness for many months.

By 1810, Appert was well versed in the preservation of foods in bottles. In that year King George III of England granted a patent to Peter Durand for his idea of preserving food in "vessels of glass, pottery, tin or other metals or fit materials." The broad material coverage of this patent is responsible for Durand being dubbed "the father of the tin can."

The early years of the nineteenth century found the canning industry trying out its "sea-legs" with the French bottling and the English canning food for their respective armies and navies. Canning was introduced to America in 1812 by two Englishmen who opened two small canning plants on the East Coast. Glass jars were used as containers for the first twenty-five years when economies dictated a switch to the cheaper and more durable tin canisters or "cans."

The can industry is similar to many others in that its first products were laboriously made by hand. In the early days of the industry, a craftsman cut the body and end blanks from a sheet of tinned iron by hand with a pair of tin shears. The body was bent into a cylinder and the side seam soldered. The bottom and top blanks were then soldered in place. The tops of these early cans had a large concentric opening through which the cans were filled and then finally sealed with a soldered circular metal disc. An experienced craftsman could make as many as six cans an hour.

The use of cans was adopted by other industries as an expedient method of packaging. The increased demand for cans promoted the development of improved manufacturing methods and by 1900 cans were being made at a rate of fifty a minute. During the last sixty years the accumulated efforts of all industries allied with canning has resulted in greatly improved equipment and techniques that permit the manufacture of over 42 billion cans annually. Laid end to end these cans would reach across the United States approximately 1000 times, or circle the earth about 100 times. The beneficial effects of this impetus upon the economic status of all types of food producers, the steel industry, the machine manufacturers and labor is obvious. Figure 1 shows a filling machine used about fifty years ago and indicates that considerable improvement has also been made in this technique.

Of the 4.6 million tons of steel that are consumed annually in metal can manufacture, 18 per cent is used for non-food items of which petroleum products is the most important. To the countless number of cans used in packaging petroleum products must be added the large number of metal drums used for the same purpose. The ready acceptance and spontaneous popularity of metal containers for the packaging of these products resulted from:

1. Economies accruing from low material, labor and shipping costs.
2. Versatility in respect to size and design.
3. Ruggedness which tolerates rough handling.
4. Packageability.
5. Printability which permits attractive packages.
6. Complete sealing which insures against tampering, contamination or adulteration.

The industrialization that has been accelerating during the past few decades has required ever increasing quantities of petroleum products — and many more cans and drums to package them. While modern containers are made in the same general manner as the original canisters, changes in seam design and replacement of hand work by precision machinery in all phases of operation has made it possible to supply the billions of cans required annually by the industry.

The fabrication of a plain can is not a simple one step process, but rather an integration of many unitized operations, each of which requires well designed sturdy machines which will perform their functions at high speeds with great accuracy.

The raw material for a can is steel sheet of various gauges which may or may not be coated with tin or other protective materials as dictated by its intended

TABLE I
TYPICAL PETROLEUM PRODUCT PACKAGES

1. DRUMS
   (a) 16, 30 and 55 gallon; 2 rolling hoops, 2" and ¾" bungs
   (b) 120, 240 and 400 pound; removable heads, quick lock ring closures
   (c) 400 pound asphalt; single or double heads
   (d) Wax: metal or fiber
   (e) 5 gallon; tightheads, handles and spouts

2. PAILS
   (a) 5 gallon; lug covers, bails and spouts

3. CANS
   (a) 5 gallon round; with retractable fittings
   (b) 5 gallon square
   (c) 2 gallon oblong
   (d) 5, 4, 1 quart; 15 and 4 ounce round
   (e) 4, 1 and ½ quart oblong
   (f) 4 quart and 9, 5 and 1 pound round friction top
   (g) 1 pound slip cover

4. MISCELLANEOUS
   (a) Vinyl lined polyethylene tubes (gear grease and oil)
   (b) Polyethylene bags (gear lubricants)
   (c) Aerosol spray cans (gear lubricants)
   (d) Fiber cartons (roofing asphalts)
   (e) Paper bags (roofing asphalts)
   (f) Cloth covering (high melting point greases)
   (g) Paper wrapping (hard greases and waxes)

usage and the material it will contain. The size of the container to be made governs the thickness of the material to be used, the larger containers requiring heavier gauge material to insure structural stability.

Consumer convenience is a vital factor in modern merchandising and accounts for the hundreds of varieties of different types and sizes of packages in use today. The large number of petroleum products having consistencies ranging from gasoline to high softening point asphalt pitches and their many specific applications dictate many packages. It is interesting to note that the domestic crimped top five gallon oil containers must be replaced in many export areas by slotted lug cover containers which serve as pails when emptied. Table I lists the containers used for the packaging of petroleum products. Most of these are metal containers and it is the lubrication of the equipment used for their manufacture and filling with which this article is concerned.

Regardless of its size and shape, a can is made by slitting the body and ends from the sheet metal, forming these to the proper shapes and assembling them. This simple description does not take into consideration a number of very exacting intermediate operations required on each of the component pieces to insure a serviceable container and which require special machines, but it will serve to clarify the general processing steps and equipment used.

It should be pointed out that the lubrication of can making equipment is not as critical as it is in some industries where high operating temperatures and pressures prevail and where lubricant contamination is a problem. Lubrication is extremely important, however, as oil-starved bearings result in wear and misalignment which cannot be tolerated. Only slight deviations from designed part dimensions may produce poor joints and seals which will result in an abnormal percentage of unusable "leakers." There are few industries where a rigid system of maintenance lubrication pays more dividends. In the can industry, as in all others, the regular application of the *right* amount of the *right* type and quality of lubricant in the *right* condition to the *right* place at the *right* time will prevent excessive mechanical wear, poor quality of product, excessive spoilage and costly downtime and equipment repairs.

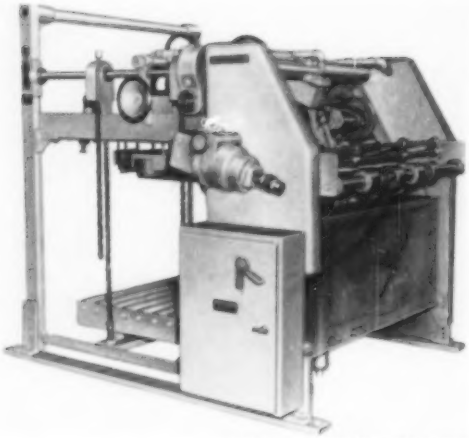
The lubrication of the many pieces of equipment required to produce metal cans and drums is unique in respect to the types of lubricants that are required and the importance of lubricant application. In spite of the rather complex synchronizing mechanisms which characterize many of the fast operating units, the entire plant can be lubricated with only a few types of oils and greases. In fact there are only a few places where lubrication is critical with respect to the type of lubricant used. Lubricant application, however, is critical in that the operations require frequent application of small quantities. Excessive amounts of lubricant may be thrown onto the sheet parts being processed and have a detrimental effect on subsequent lithographing and sealing operations.

BODY MAKING

The initial step in converting sheets of steel into can bodies, bottoms and tops is the application of the multi-colored designs and printing which decorate the package and identify its contents. This operation uses five specific pieces of equipment: metal sheet feeder, lithographing press, bake oven, slitter and body maker.

Metal Sheet Feeder

This unit is used in all operations where flat sheets are fed to machines for processing. As indicated in Figure 2, a stack of metal sheets weighing as much as four tons is placed on a platform which auto-



Courtesy of The Dexter Company

Figure 2 — High Speed metal sheet feeder.

matically elevates and maintains the top sheet at the correct height for feeding. An air jet impinging on the sheet edges helps to separate the top sheet. Rubber suction cups located on each side of the feeder, and evacuated by a vacuum pump, then grip it, raise it and move it forward into the machine to which the feeder is attached. These units are designed to feed sheets at a rate of 150 per minute and operate much like their cousins in the paper-printing industry.[1]

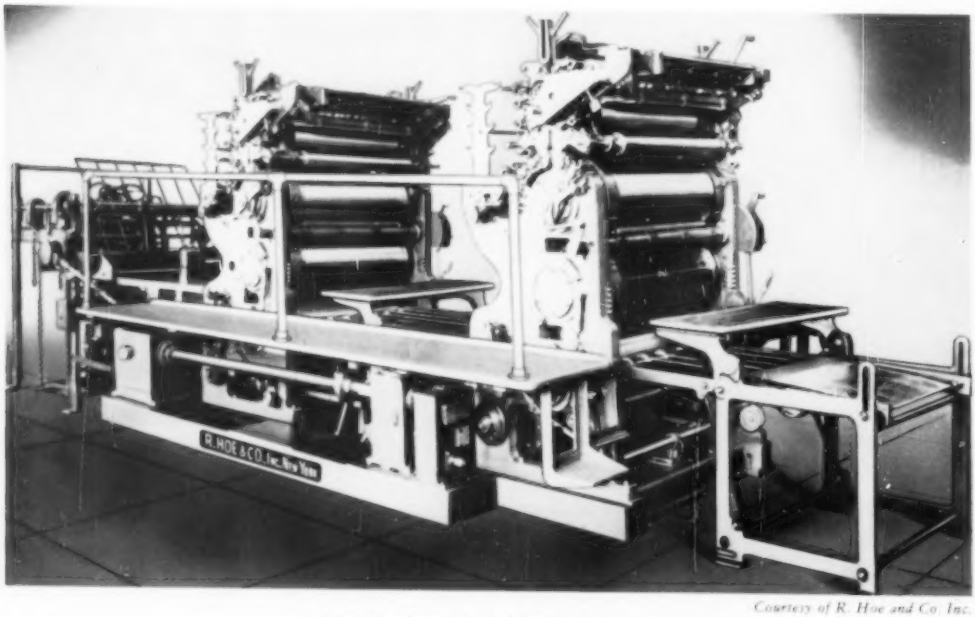
Metal sheet feeders have many moving parts which would normally require frequent lubrication; however this maintenance is greatly simplified by use of oil-impregnated porous bushings, sealed anti-friction bearings and graphite bronze plain bearings. Points requiring daily lubrication may be equipped with oil or grease cups, grease fittings, or automatic lubricators set to deliver small increments of oil at specific intervals. Gears and bearings on feeders are not critical in respect to the types of lubricants: an oil having a viscosity of about 550 SUS @ 100° F. (for example an SAE 30 motor oil) and a multi-purpose grease of NLGI No. 2 grade are usually quite adequate.

The self-contained air pressure and vacuum pumps in feeders are more critical in respect to lubrication. Care must be exercised to insure sufficient oil to maintain pressure or vacuum. Pumps must be flushed periodically to remove accumulations of foreign material and compressor oil must be kept out of the discharge air stream lest it soil the metal sheet and impair its printing characteristics.

Lithographing Press

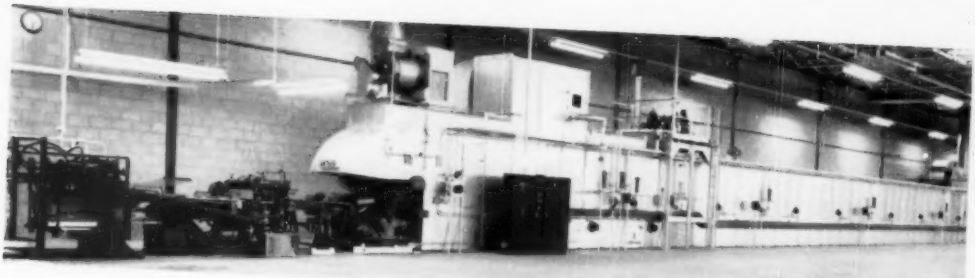
These presses are either single or two-color units (like that shown in Figure 3) for the application of one or two colors respectively to sheets that have previously been given a white base coating. A typi-

[1] Magazine Lubrication, Dec. 1959 issue, "Printing Lubrication"



Courtesy of R. Hoe and Co. Inc.

Figure 3 — Two-color metal decorating press.



Courtesy of Wagner Litho Machinery Div.

Figure 4 — Rotary air oven for drying lithographed metal sheets. Note sheet feeder and coater at the left.

cal unit consists of plate, blanket and impression rolls for transferring the enamel from the reservoir to the design plate and thence onto the sheet being processed. A number of can bodies are printed on a single sheet and subsequently separated. When more than one color is printed, the successive color plates must be precisely "registered" to prevent overprinting. The required synchronization between presses or units within the same press is obtained by gear drives.

Substantial construction, use of wear resistant metals, and efficient lubrication are all mandatory for efficient press performance, though lubricant types are not critical. A multi-purpose grease of NLGI No. 2 grade or a lubricating oil having a viscosity of about 550 SUS @ 100°F. is adequate for bearing lubrication. Since gears are conservatively loaded, a straight mineral oil having a viscosity of about 3000 SUS @ 100°F. is usually adequate.

Bake Oven

All printed metal sheets leaving the lithographing presses must be baked to dry and harden the coating so they can be stacked for subsequent operations. This is done in a continuous bake oven which is frequently over 170 feet long with widths and heights of approximately 12 feet as illustrated in Figure 4. The oven is fabricated from metal panels backed with three inches of insulation to minimize heat losses, and equipped with gas or oil fired heaters and air circulating blowers located so as to divide it into sections of graduated temperature. Temperatures may be as high as 450°F. and are accurately controlled by thermostats.

The sheets are automatically fed onto an endless roller-chain conveyor equipped with tubular steel wickets which support the sheets in an essentially vertical position and move them through the oven at a rate as high as 150 sheets per minute. High temperatures and the gradual movement of air countercurrent to the sheet travel insure complete baking and elimination of paint solvent vapors from the final sections.

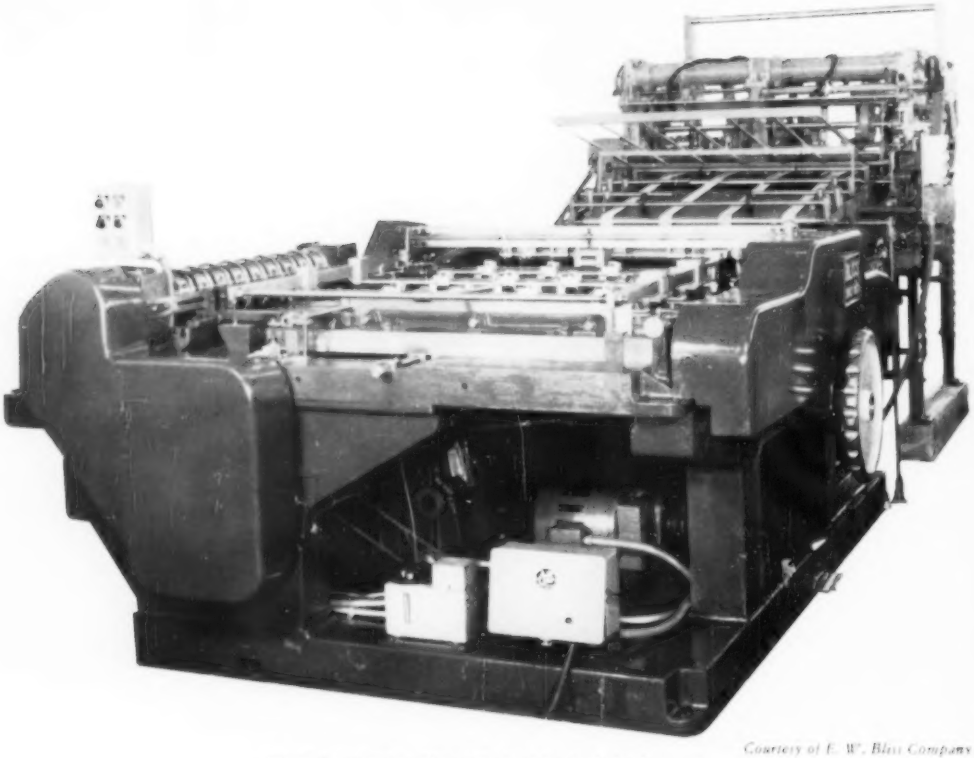
The high temperatures to which the chains are exposed make their lubrication extremely critical. All petroleum lubricants are susceptible to oxidation when exposed in thin films to high temperatures. This characteristic can be minimized by the selection of crudes, refining procedures and the incorporation of additive materials. The oxidation of lubricants is accompanied by an increase in viscosity and the ultimate formation of carbonaceous and varnish-like materials. All three oil oxidation effects impair the lubrication of conveyor roller chains in bake ovens by increasing wear and power input requirements. Excessive lubrication also results in sludge and carbon formation and must be avoided. Application of minimum amounts of an extremely heat stable oil like the SAE 30 grade of a "heavy duty" detergent motor oil is necessary to obtain satisfactory results.

The many motor-driven fans located on both sides of the oven operate at much higher than normal temperatures and require special consideration in respect to lubrication. Grease-lubricated motor bearings in this service require the NLGI No. 2 or No. 3 grade of a grease having a high dropping point and exceptionally high heat resistance.

Bearings and gears on these units that are not exposed to high temperatures can be satisfactorily lubricated with the lubricants suggested for lithographing presses.

Slitters

The lithographed sheets with their multiple printings of can bodies must be cut into individual body blanks before further processing. This is done on a slitter like that shown in Figure 5 in which circular tungsten-carbide "knives" perform the cutting operation in either one or both directions depending on machine design and the size of body blanks being processed. The knives are spaced along the slitter shafts which are mounted on antifriction bearings. Adjustable idler bearings are frequently placed at the middle of the shafts to prevent misalignment. In older machines the replacement of plain bearings with antifriction bearings has minimized adjustments necessary due to bearing wear and extended the period between knife sharpenings. A multi-



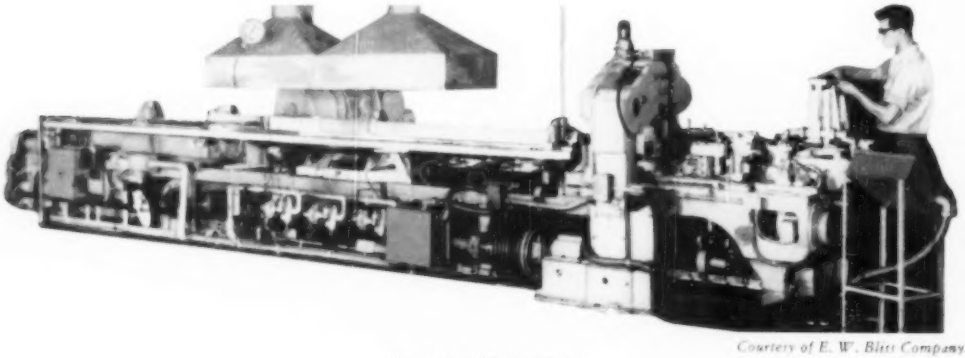
Courtesy of E. W. Blatz Company

Figure 5 — Duplex slitter with sheet feeder in background.

purpose oil of about 300 SUS viscosity at 100°F. and a multi-purpose grease of NLGI No. 2 grade provide satisfactory lubrication.

Body Makers

The processing steps required to produce single lithographed can body blanks can be considered as auxiliary operations to the actual can making which starts with the body makers. This also applies to the several operations required to produce the ends, caps, spouts and handles. Formation of the can bodies may be considered as the heart of the operation and care must be exercised to insure maximum production efficiency of the equipment used. The



Courtesy of E. W. Blatz Company

Figure 6 — Body maker.

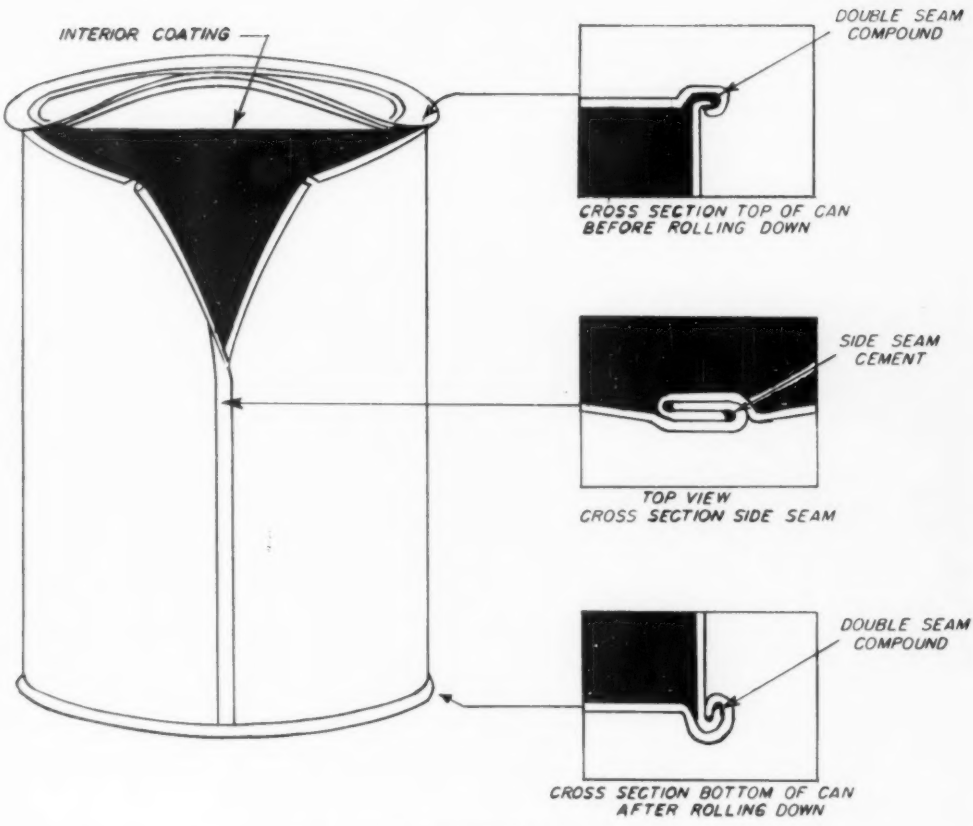

INTERIOR COATING
DOUBLE SEAM COMPOUND
CROSS SECTION TOP OF CAN BEFORE ROLLING DOWN
SIDE SEAM CEMENT
TOP VIEW
CROSS SECTION SIDE SEAM
DOUBLE SEAM COMPOUND
CROSS SECTION BOTTOM OF CAN AFTER ROLLING DOWN

Figure 7 — Seam construction in a quart motor oil can.

importance of one of these units in the integrated operation is readily recognized when one considers its throughput of 15,000 can bodies an hour. Single units, such as shown in Figure 6, are designed to make different sizes of round, square and rectangular can bodies.

In spite of the speed at which the body maker operates, the procedure is complicated and the finished product must meet exacting requirements. Each operation is synchronized by take-offs from the main crankshaft. Body blanks are fed to the machine by a metal sheet feeder and are subjected to flexing, slitting and notching operations prior to rolling into the can body. The body seam can be made leakproof either by soldering or welding, or by using an oil-insoluble resinous cement as illustrated in Figure 7. The latter is used on one-quart non-refillable motor oil cans while soldered seams are used on the larger sized containers due to the greater flexibility of their longer seams. Perfectly square rolling and thorough sealing of body joints are necessary to minimize leaky containers which would be rejected in subsequent test machines.

The same oils and greases used on the feeders and slitters are used in the body makers. The high capacity of these units and the high value assessed to production time makes it very economical to install some type of centralized lubricating system.

The final step in body construction is done on the flangers which flare the top and bottom one eighth inch of each can body outward to receive the can top and bottom. This is accomplished by forcing flanging dies into both ends of the can body simultaneously.

CAN BOTTOMS AND TOPS

Plain can bottoms and tops are made in a four step operation, as follows:

1. Metal sheets are cut into strips of the desired width by scroll shears. (The edges are scrolled or "waved" rather than straight-cut in order to reduce waste during subsequent operations).

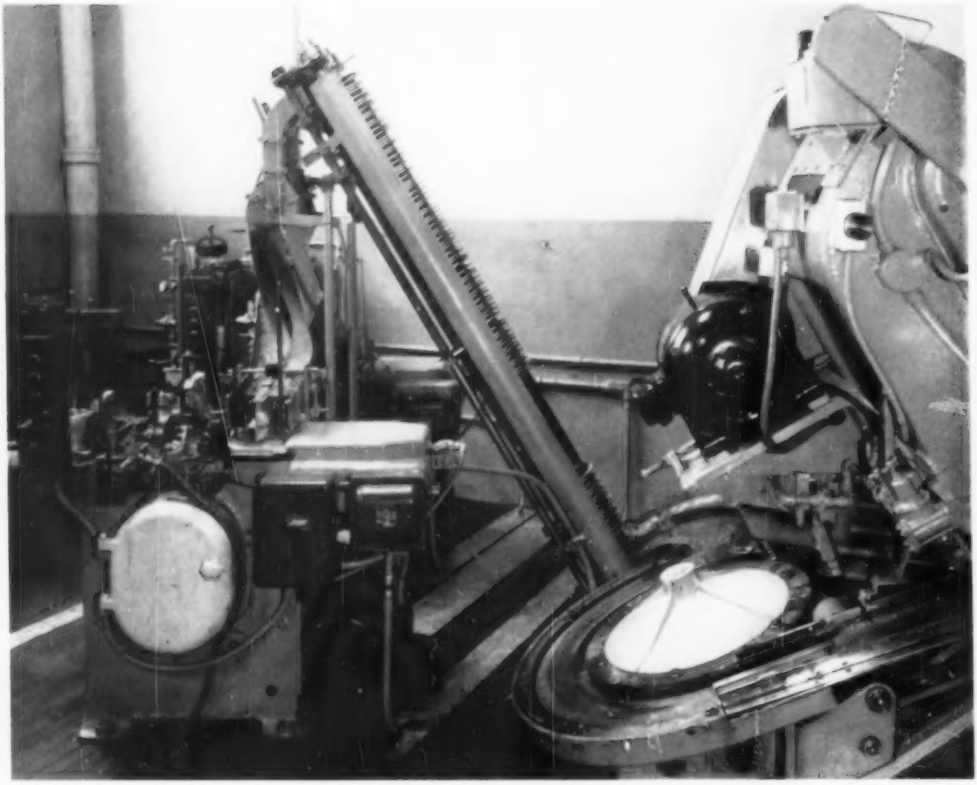


Figure 8 — End press, curler and liner.

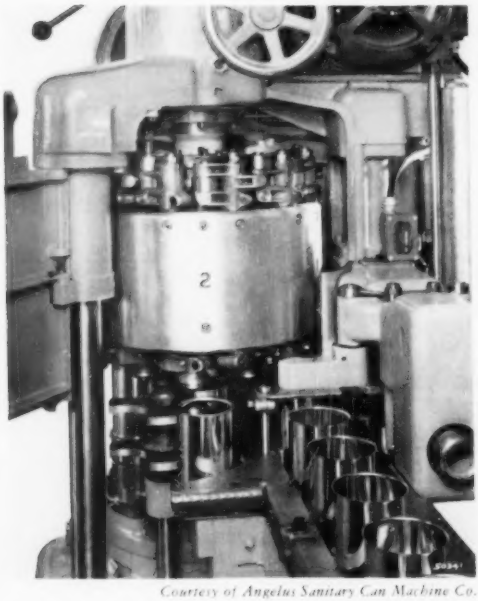
2. Blanks for tops and bottoms are punched from the scrolled strips by means of double-die automatic end presses.
3. The edges of the blanks are bent inward or "curled" by means of curlers as indicated in Figure 7 to facilitate the seaming operation when the end is applied to the can body.
4. The future seam is "lined" by placing a thin narrow band of double-seam compound in the curled ends where contact will be made with the can body.

From right to left Figure 8 shows an end press, curler, spiral elevator and liner which are mainly lubricated with the SAE 90 grade of an EP gear oil. The scrolling and blanking machines are the only ones subjected to appreciable working pressures; consequently their main crankshaft and connecting rod bearings must receive frequent lubrication (usually with the SAE 140 grade of an extreme pressure gear oil) to prevent wear and malfunction.

Auxiliary Can Top Fixtures

The manufacture of cans for the packaging of petroleum products may be considerably more complicated than the just-described simple assembly of two ends and the body. Complications are caused by the many modifications of the can tops such as screw-top pouring spouts of several designs which are required on the larger cans, together with the application of bails or handles. For example, Figure 9 is an exploded view of the twenty-seven steps required to make a rectangular recloseable gallon can.

Figure 9 — Exploded view illustrating the 27 successive steps required to manufacture and assemble the one gallon can shown in the foreground.



Courtesy of Angelus Sanitary Can Machine Co.

Figure 10 — Seamer assembling can bottoms to bodies.

SEAMER

After fabricating a sufficient quantity of can bodies and ends, the process of assembling cans from these parts begins. The first step consists of putting the bottoms on the can bodies which is performed continuously by the seamer, illustrated in Figure 10. Can bodies enter the machine in the right foreground while bottoms are automatically placed on them from the stack at the upper right. The loose assemblies of can bodies and bottoms run under a turret carrying multiple vertical seaming spindles with roller heads which engage the can parts and roll a tight seam in a single turret revolution. A seamer is of substantial construction with the spindles operating on antifriction bearings to prevent any misalignment which would result in faulty seam formation.

CAN TESTER

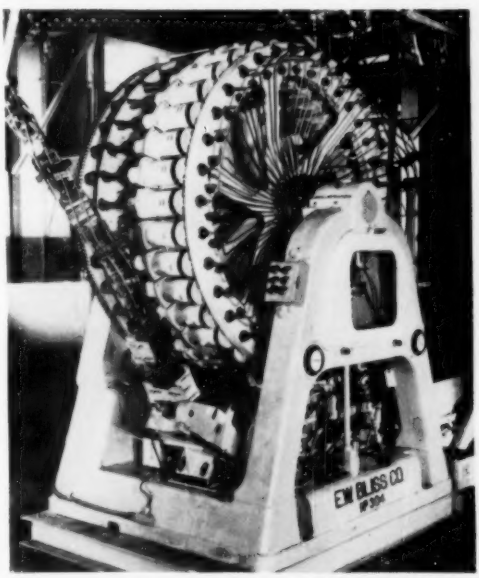
Prior to filling, the bottom-body assemblies of all cans are pneumatically tested in order to reject any with faulty construction which would result in "leakers" after filling. Figure 11 shows a typical 36 bucket tester used for this purpose.

The cans are fed continuously to the unit by gravity through a spiral feed-line chute. In the machine, the flange at each top is clamped against a soft rubber disc. An outer chamber or "bucket" then encloses the can and seals itself on a rubber disc, creating a sealed enclosure around the can. When compressed air is shot into the can at a predetermined pressure, any leakage through it into the bucket raises the pressure in the latter. Even a very slight increase in bucket pressure activates an electro-mechanical rejecting device which literally kicks the faulty can out of the machine. The device easily detects pin-hole size holes that can not be seen and its proper functioning is frequently checked by deliberately inserting marked cans known to have pinholes into the feed line.

CAN FILLING EQUIPMENT

Empty cans are light but very bulky, consequently they are filled immediately after manufacture not only to minimize can storage facilities but also to reduce the possibility of dust, dirt or extraneous material getting into the can which would contaminate its oil. The final two steps of filling the can and immediately sealing it by applying its top are both carried out in the unit shown in Figure 12.

The filling equipment consists of an open cylindrical tank approximately three feet in diameter in which the oil is maintained at a constant level by means of an overhead supply line. Multiple oil dispensing cylinders equipped with rapid opening and closing valves are located around the outside periphery of the oil reservoir. The valves are activated by rollers riding on a circular inclined track. The opening and closing of the valves are adjusted for extremely accurate oil volume delivery by varying the pitch of the valve track. As the cylinders revolve, they are filled from the oil reservoir and emptied



Courtesy of E. W. Bliss Company

Figure 11 — Thirty-six bucket can tester.

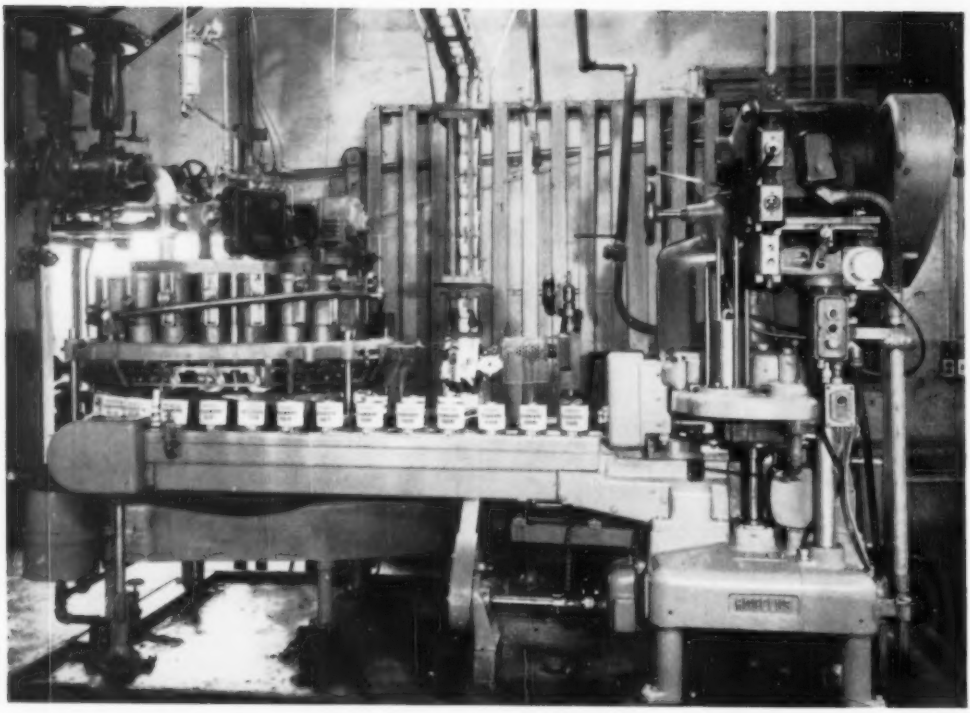


Figure 12 — Can filler and top seamer.

into the cans which travel along below them. Since oil flow is a function of its viscosity which in turn is affected by temperature, these variables must be considered in can filling and proper equipment adjustments made to insure full measures. Modern units are capable of filling 18,000 cans an hour. In fact, can speeds are so high that "banking" of curves in the track is required to prevent cans from being thrown off the machine.

The filled cans are fed directly into a "second seamer" shown at the right of Figure 12 which places the tops on the cans and rolls the top seams. This unit has the additional function of stamping the SAE viscosity grade of oil on the can top just before placing it on the can.

The above double operation requires the same perfect synchronization which characterizes other units used in can making. This is obtained by using a single drive with properly designed take-offs for the component parts.

The filled cans are now packed in cartons or otherwise protected for distribution. Figure 13 shows a few of the many sizes and styles of cans used in packaging petroleum oils.

DRUMS

The manufacture and filling of the five to fifty-five gallon drums are basically the same as for the smaller cans. The larger size, however, dictates the

Figure 13 — Representative petroleum packages.

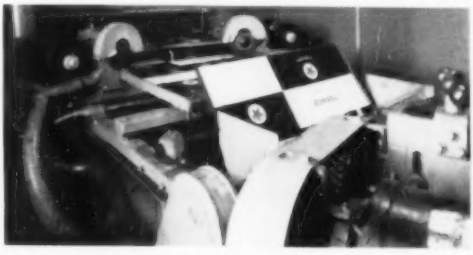


Figure 14 — Grinding edges of body sheets prior to welding.

Figure 15 — Drum filling operation.

use of welded seams which are formed continuously with a welding wheel. Considerable care must be exercised to insure uniform welding, however, since these containers are not usually tested for leaks. Prior to welding, the body edges are thoroughly cleaned by grinding as shown in Figure 14.

The lubrication of drum making equipment is comparable to that of the can units. The only critical location is in the bake ovens where unusually high temperatures prevail.

Figure 16 — Plastic tube for outboard motor gear grease which simplifies injection of grease into gear case.

Figure 17 — Old and new methods for applying lubricant to electric traction motor. The plastic lubricant container disintegrates during operation and contributes to gear lubrication.

The drum filling operation is much slower and more laborious than for the small cans, since it is accomplished by weighing a predetermined amount of oil into each drum using the equipment shown in Figure 15.

PACKAGE TYPES

Petroleum products requiring packaging vary from very low viscosity oils to hard, brittle asphalts having very high softening points. Thus the type of packaging is governed by the physical properties of the petroleum product and convenience in ultimate use. Improvement in the ease with which products can be handled by the consumer has given impetus to many new types of packages. Some of these are listed under "Miscellaneous" in Table I which shows a few of the large number of packages used for petroleum products. Figures 16 and 17 picture two of the newer packages, both of which illustrate improvement in the ease of product application.

Due to their low cost, their convenient size and the ease with which they can be removed, fiber cartons are now used to package roofing asphalts. The filling of these is shown in Figure 18. However, extremely friable high softening point asphalts require no packaging; instead they are cast into 1000 pound cakes which are cooled and then broken into lumps for bulk shipment in gondola cars. The cakes can be readily broken into the desired size by merely dropping them on uniformly-spaced rails like those in Figure 19 which permit the smaller pieces to fall through into the cars.

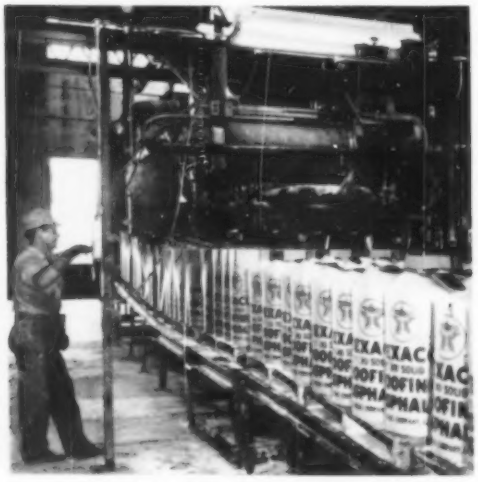


Figure 18 — Packaging of roofing asphalt.

Figure 19 — Breaking cakes of very hard asphalt for bulk shipment.

LUBRICATION

The importance of adhering to a well organized system of lubrication has been mentioned several times. Individual hand lubrication of the many bearings and gears, which are frequently inaccessible, is not only a tedious chore, but highly dangerous since much must be done while the machines are operating. In order to circumvent this situation many of the units are being equipped with mechanical lubricating systems[2] which feed measured amounts of oil or grease at definite intervals to the parts to be lubricated. Hidden bearings which are grease lubricated through pressure fittings can be insured of receiving regular lubrication by locating the pressure fittings on an accessible panel board and connecting them to the bearings by metal tubing. The pumpability and stability characteristics of a grease may be critical in these units, therefore it is desirable to use a lithium soap multi-purpose grease of the NLGI No. 2 grade.

SUMMARY

Considerable research[3] is underway to improve the packages used by the petroleum industry. This includes the use of new package materials and package design. Considerable attention is being given to packaging which will facilitate handling by the consumer and should result in many improvements in the future.

Though it normally operates at high speeds, packaging machinery is so well designed and of such substantial construction that (excepting ovens) it can usually be lubricated with conventional oils and greases. More extensive use of centralized lubrication systems is indicated however.

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[2] Magazine Lubrication: Sept. 1950, "Grease Application Devices," July 1958, "Organized Plant Lubrication," Nov. 1957, "Central Air-Borne Lubrication Systems"

[3] Magazine Lubrication, December 1957, "Package Research"

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